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April 20, 1993

Mr. Gary Gamble
Hecla Mining Company
6500 Mineral Drive
Coeur d'Alene, ID 83814

Subject: HELP Model Results for Modified Cover Scenarios
GSA Correspondence No. 610449.152

Dear Gary:

Grant, Schreiber and Associates (GSA), together with our parent company, James L. Grant and Associates, Inc. (JLGA), is pleased to submit the results of the infiltration modeling of three modified cover scenarios that you requested for Hecla's Escalante Unit tailings impoundment located near Enterprise, Utah. This report presents the data and assumptions used to model the impoundment and cover, and the modeling results.

GSA used the Hydrologic Evaluation of Landfill Performance (HELP) Model[1,2] to simulate movement of water through the soil layers for the modified cover conditions presented in Table 1.

The purpose of the modified cover scenarios is to evaluate the performance of the cover with a thicker subsoil layer and a capillary barrier layer taking the place of the previoulsy proposed clay cap layer.

Table 1. Modified impoundment cover scenarios.

Scenario No.	Layer Thickness (inches)		
	Topsoil	Subsoil	Capillary Barrier
1	6	6	12
2	6	12	6
3	6	18	0

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1 Schroeder, P.R., J.M. Morgan, T.M. Walski, and A.C. Gibson, *The Hydrologic Evaluation of Landfill Performance (HELP) Model Volume 1 - User's Guide for Version 1*, prepared by U.S. Army Engineer Waterways Experiment Station for the U.S. Environmental Protection Agency Office of Solid Waste, Washington, D.C., August 1983.

2 Schroeder, P.R., *User's Guide for HELP Version 2*, prepared by U.S. Army Engineer Waterways Experiment Station for the U.S. Environmental Protection Agency Office of Solid Waste, Washington, D.C., February 1988.

ᴗLIMATIC DATA

The climatic data used in the simulation were the same as previously used by GSA[3] to model the impoundment cover conditions.

SOIL DESIGN DATA

The soil design data used in the model are presented in Table 2. The properties of the tailings, underdrain, and foundation soil layers are the same as previously used by GSA[3] to model the impoundment. The properties of the topsoil layer are the same as used in previous simulations, with the exception of the layer thickness, which was changed from four inches to six inches.

The parameters used to model the subsoil layer were modified to account for the different process in which the subsoil would be obtained. Although the same borrow areas will likely be used, the original plan called for segregating the borrow soil into subsoil and clay cap material. Because the portion of the borrow soil containing more clay would be removed and used for the previously proposed cap layer, the remaining borrow soil (for the subsoil layer) would be more gravelly. Therefore, the physical parameters used to model the subsoil layer were modified to reflect the finer nature of the subsoil layer. The subsoil parameters are based on soil testing conducted by GSA[4] and Fox[5]. Based on testing conducted by GSA, the typical porosity of soils in the potential borrow area is about 40 percent. Fox conducted several shallow (four feet deep) field permeability tests in the vicinity of the impoundment. These tests indicated that the mean permeability at this depth is about 10^{-5} cm/sec.

The capillary barrier will be constructed of waste rock from the mine. The parameters used to model this layer are typical of gravelly soils[2].

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[3] Grant, Schreiber and Associates, *Cyanide Transport Modeling - Escalante Mine Tailings Impoundment, Enterprise, Utah*, unpublished report prepared for Hecla Mining Company, June 28, 1991.

[4] Grant, Schreiber and Associates, *Geotechnical Investigation for Impoundment Cap Borrow Material - Escalante Mine Tailings Impoundment*, unpublished report prepared for Hecla Mining Company, November 12, 1991.

[5] Fox, F.M. and Associates, Inc., *Geotechnical Investigation for the Proposed Mill and Tailing Disposal Areas, Escalante Project - Iron County Utah, unpublished report prepared for Ranchers Exploration and Development Corporation*, May 14, 1980.

Table 2. Soil design data for the impoundment and modified cover.

Layer	Porosity	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Initial Water Content (%)	Saturated Hydraulic Conductivity (cm/sec)
Topsoil	0.398	0.244	0.136	14.0	1.2×10^{-4}
Subsoil	0.40	0.20	0.136	19.0	1×10^{-5}
Capillary Barrier	0.417	0.045	0.02	5.0	1×10^{-2}
Tailings	0.49	0.378	0.265	30.0	1.9×10^{-5}
Underdrain	0.41	0.378	0.10	13.2	1×10^{-3}
Foundation Soil	0.41	0.20	0.10	15.1	5.67×10^{-7}

MODEL RESULTS

The results of the HELP model simulations for Scenarios 1, 2, and 3 are presented in Tables 3, 4, and 5, respectively. These results show that, over a 20-year period, the percolation into the tailings decreases with increasing thickness of the subsoil layer. For Scenarios 1, 2, and 3, the thickness of the subsoil layer was increased from six inches to 12 inches to 18 inches, respectively. The average annual percolation from the capillary barrier into the tailings decreased from 0.1058 to 0.0355 to 0.0006 inches for Scenarios 1, 2, and 3, respectively.

Comparing Scenarios 1 and 2, doubling the thickness of the subsoil layer reduced the quantity of water reaching the tailings by a factor of three. Similarly, tripling the thickness of the subsoil layer (Scenarios 1 and 3) reduced the quantity of water reaching the tailings by a factor of about 180.

The previous HELP simulations[3] of the reclaimed impoundment indicated an average of 0.0839 inches per year of water percolating through the clay cap layer over the same 20-year period. Comparing this with the results of the modified cover scenarios indicates that a six-inch modified subsoil layer (Scenario 1) is nearly as effective in reducing percolation into the tailings as the six-inch clay cap layer (0.1 inches versus 0.08 inches). Given the sensitivity of the HELP model and variability of the input parameters, there is essentially no difference between these two cases. However, this is largely a result of the arid climate. In both cases, over 98.5 percent of the average annual precipitation is removed from the impoundment by evapotranspiration (95.22 percent) and surface runoff (3.40 percent). The remaining 1.38 percent of the average annual precipitation that is available to migrate downward to the tailings is only 0.144 inches. Therefore, regardless of the configuration of the cover, the quantity of water that can potentially enter the tailings is small. In the Scenarios 2 and 3, the quantity of water removed by evapotranspiration and surface runoff is even greater (99.36 and 99.74 percent, respectively).

Table 3. HELP model results for cover modification Scenario 1.

Year	Precip-itation (inches)	Runoff (inches)	Evapotran-spiration (inches)	Percolation from Capillary Barrier (inches)	Percolation from Under-drain (inches)	Percolation from Liner (inches)	Percolation from Foundation Soil (inches)
1	8.24	0.123	7.994	0.0340	0.0000	0.0000	0.0352
2	9.89	0.125	9.322	0.0000	0.0000	0.0000	0.0351
3	11.23	0.185	10.785	0.4899	0.0000	0.0000	0.0351
4	6.80	0.002	7.396	0.0000	0.0000	0.0000	0.0351
5	9.83	0.307	8.210	0.0000	0.0000	0.0000	0.0350
6	15.71	0.647	15.477	0.0000	0.0000	0.0000	0.0349
7	15.45	0.582	14.554	0.0000	0.0000	0.0000	0.0349
8	11.97	0.419	11.423	0.1607	0.0000	0.0000	0.0349
9	7.50	0.007	8.696	0.0000	0.0000	0.0000	0.0348
10	12.59	1.396	10.245	0.0000	0.0000	0.0000	0.0348
11	8.79	0.042	9.152	0.2288	0.0000	0.0000	0.0347
12	12.15	0.230	11.275	0.0000	0.0000	0.0000	0.0348
13	11.97	0.479	11.854	0.6387	0.0000	0.0000	0.0346
14	7.68	0.471	6.845	0.0000	0.0000	0.0000	0.0346
15	8.78	0.144	8.340	0.0000	0.0000	0.0000	0.0345
16	9.02	0.054	8.099	0.0000	0.0000	0.0000	0.0346
17	16.32	1.342	15.559	0.5631	0.0000	0.0000	0.0344
18	12.00	0.417	11.626	0.0000	0.0000	0.0000	0.0344
19	5.22	0.033	5.554	0.0000	0.0000	0.0000	0.0343
20	7.20	0.071	5.965	0.0000	0.0000	0.0000	0.0344
Total	208.34	7.076	198.371	2.1152	0.0000	0.0000	0.6951
Percent	100.00	3.40	95.22	1.02	0.00	0.00	0.33
Average	10.42	0.354	9.919	0.1058	0.0000	0.0000	0.0348
St . Dev.	3.103	0.401	2.913	0.2078	0.0000	0.0000	0.0003

TOPSOIL - 6
SUBSOIL - 6
WASTEROCK - 12

Table 4. HELP model results for cover modification Scenario 2.

Year	Precip-itation (inches)	Runoff (inches)	Evapotran-spiration (inches)	Percolation from Capillary Barrier (inches)	Percolation from Under-drain (inches)	Percolation from Liner (inches)	Percolation from Foundation Soil (inches)
1	8.24	0.123	8.098	0.0747	0.0000	0.0000	0.0352
2	9.89	0.125	9.322	0.0000	0.0000	0.0000	0.0351
3	11.23	0.200	11.279	0.0266	0.0000	0.0000	0.0351
4	6.80	0.001	7.365	0.0000	0.0000	0.0000	0.0351
5	9.83	0.310	8.199	0.0000	0.0000	0.0000	0.0350
6	15.71	0.647	15.477	0.0000	0.0000	0.0000	0.0349
7	15.45	0.579	14.525	0.0000	0.0000	0.0000	0.0349
8	11.97	0.417	11.474	0.0000	0.0000	0.0000	0.0349
9	7.50	0.007	8.744	0.0000	0.0000	0.0000	0.0348
10	12.59	1.384	10.345	0.0000	0.0000	0.0000	0.0348
11	8.79	0.061	9.227	0.0000	0.0000	0.0000	0.0347
12	12.15	0.250	11.008	0.0000	0.0000	0.0000	0.0348
13	11.97	0.534	12.243	0.5932	0.0000	0.0000	0.0346
14	7.68	0.470	6.873	0.0000	0.0000	0.0000	0.0346
15	8.78	0.144	8.299	0.0000	0.0000	0.0000	0.0345
16	9.02	0.054	8.108	0.0000	0.0000	0.0000	0.0346
17	16.32	1.390	16.022	0.0157	0.0000	0.0000	0.0344
18	12.00	0.422	11.659	0.0000	0.0000	0.0000	0.0344
19	5.22	0.031	5.345	0.0000	0.0000	0.0000	0.0343
20	7.20	0.065	6.177	0.0000	0.0000	0.0000	0.0344
Total	208.34	7.214	199.789	0.7102	0.0000	0.0000	0.6951
Percent	100.00	3.46	95.90	0.34	0.00	0.00	0.33
Average	10.42	0.361	9.989	0.0355	0.0000	0.0000	0.0348
St . Dev.	3.103	0.405	2.977	0.1324	0.0000	0.0000	0.0003

TOPSOIL - 6
SUBSOIL - 12
WASTEROCK - 6

Table 5. HELP model results for cover modification Scenario 3.

Year	Precipitation (inches)	Runoff (inches)	Evapotranspiration (inches)	Percolation from Capillary Barrier (inches)	Percolation from Underdrain (inches)	Percolation from Liner (inches)	Percolation from Foundation (inches)
1	8.24	0.124	8.321	0.0000	0.0000	0.0000	0.0352
2	9.89	0.125	9.318	0.0000	0.0000	0.0000	0.0351
3	11.23	0.200	11.311	0.0000	0.0000	0.0000	0.0351
4	6.80	0.002	7.381	0.0000	0.0000	0.0000	0.0351
5	9.83	0.306	8.189	0.0000	0.0000	0.0000	0.0350
6	15.71	0.656	15.469	0.0000	0.0000	0.0000	0.0349
7	15.45	0.572	14.455	0.0000	0.0000	0.0000	0.0349
8	11.97	0.408	11.449	0.0000	0.0000	0.0000	0.0349
9	7.50	0.007	8.077	0.0000	0.0000	0.0000	0.0348
10	12.59	1.423	10.967	0.0000	0.0000	0.0000	0.0348
11	8.79	0.065	9.347	0.0000	0.0000	0.0000	0.0347
12	12.15	0.240	10.763	0.0000	0.0000	0.0000	0.0348
13	11.97	0.582	13.064	0.0112	0.0000	0.0000	0.0346
14	7.68	0.472	6.886	0.0000	0.0000	0.0000	0.0346
15	8.78	0.144	8.234	0.0000	0.0000	0.0000	0.0345
16	9.02	0.049	7.910	0.0000	0.0000	0.0000	0.0346
17	16.32	1.386	16.291	0.0000	0.0000	0.0000	0.0344
18	12.00	0.423	11.637	0.0000	0.0000	0.0000	0.0344
19	5.22	0.018	5.296	0.0000	0.0000	0.0000	0.0343
20	7.20	0.076	6.154	0.0000	0.0000	0.0000	0.0344
Total	208.34	7.278	200.519	0.0112	0.0000	0.0000	0.6951
Percent	100.00	3.49	96.25	0.01	0.00	0.00	0.33
Average	10.42	0.364	10.026	0.0006	0.0000	0.0000	0.0348
St . Dev.	3.103	0.412	3.064	0.0025	0.0000	0.0000	0.0003

We appreciate the opportunity to work with you on this project. If you have any questions or need further information, please contact us.

Very truly yours,

Grant, Schreiber & Associates

TOPSOIL - 6
SUBSOIL - 18
WASHROCK - 0

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